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THE EFFECT OF CERTAIN METHODS OF POTATO CULTIVATION ON GROWTH AND YIELD AND ACCOMPANYING SOIL CONDITIONS

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The general subject of cultivation has been given much attention by investigators as evidenced by the vast amount of literature on the subject. Most of the research has been carried on with crops other than potatoes and any differences in yield were assumed to be due mostly to moisture, but few actual measurements were made. The knowledge of the effect of cultivation on root growth is very limited, particularly with potatoes—a crop produced with all degrees of ridging, from none to extremely high ones. Certainly this should be expected to exert an influence on yield since differences in behavior of plants are manifested directly or indirectly through the roots.

Thompson (4) and many others have indicated the apparent fallacy of some of the supposed benefits of frequent tillage. Little evidence has been presented to support the moisture conservation theory. The studies do not seem to confirm the theories of the benefits derived from soil aeration and of increasing the availability of plant food content of the soil. Based upon this experimental evidence, it would seem that potato cultivation, particularly of the ridge type, when continued beyond the point of weed control on a field well prepared prior to planting, would be detrimental to the growth and yield of the crop.

The experiment upon which this paper is based was planned to test the comparative merits of a number of methods of planting and subsequent cultivation of potatoes. Root growth, soil temperature, moisture

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and nitrates (indicative of aeration) were measured in order to determine their relative influence on any yield differences which might occur. Smooth Rural potatoes were grown at Ithaca, New York, on silty clay loam for three years, 1932 to 1934 inclusive, and on gravelly loam with irrigation facilities in 1934 only.

The three principal cultural treatments studied were:

1. Deep planting (4 inches below initial soil surface) and level culture.

2. Shallow planting (1 to 2 inches below initial soil surface) and moderate ridge culture (4 inches above seed piece).

3. Shallow planting (1 to 2 inches below initial soil surface) and extreme ridge culture (7 to 8 inches above seed piece).

Treatment 2, shallow covering (1 to 2 inches), was compared with treatment 1, deep or full covering (4 inches) to determine the influence on the rate of emergence.

Horse cultivation was given every two weeks until tuber-setting, the implement used depending upon the type of culture. A shovel-plow was used for the extreme ridging, whereas a one-horse cultivator with wings sufficed for the moderate ridges. No cultivation was given in 1932 and at all times weeds were kept removed by shallow hand hoeing or scraping. In 1933 scraping with no cultivation to control weeds was compared with the horse cultivation.

Spraying in 1932 and 1934 and dusting in 1933 with Bordeaux, including calcium arsenate when necessary, every two weeks controlled all late blight and potato beetles.

Fertilization consisted of home-mixed 5-10-5 at the rate of 1000 pounds to the acre broadcast prior to planting. This followed a cover crop of rye plowed under when 8-10 inches tall.

Effect of Depth of Planting on Rate of Emergence

When conditions of temperature, rainfall, and soil moisture are favorable, the differences in effect of depth of planting and covering are at a minimum. These conditions were more nearly ideal in 1932 and 1933 than in 1934 when only 0.53 inches of rain fell in the month of May when the potatoes were planted. This is very deficient when compared with the normal of 3.4 inches for the month. Figure 1 shows the rate of emergence for 1934. Deep planting, with shallow covering, was most favorable for rapid germination in this as well as the two previous years, with shallow planting and deep covering at the other extreme. This latter type is the treatment usually followed by growers who practice ridge culture.

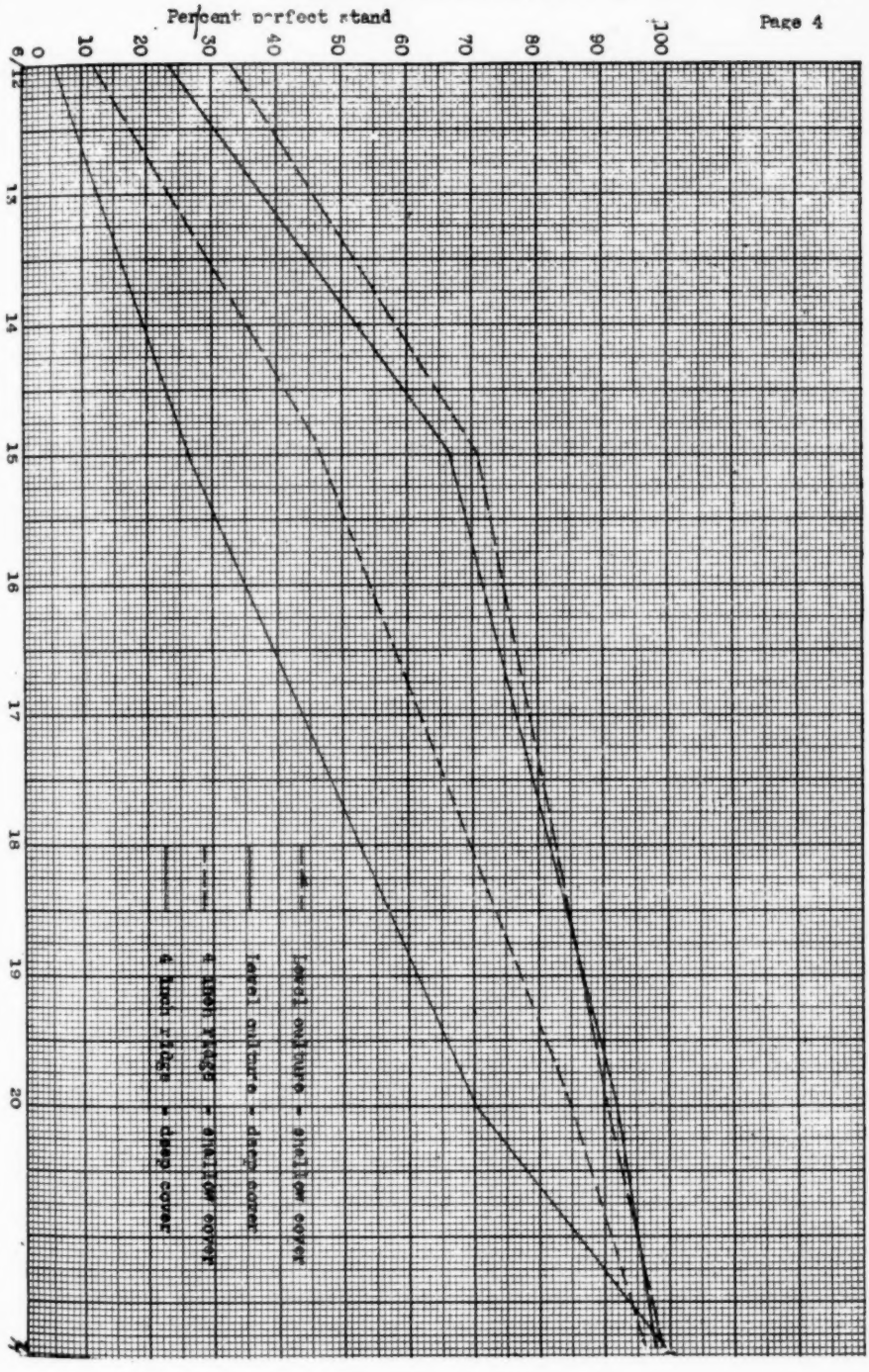

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FIGURE 1—RATE OF EMERGENCE OF SEED PLANTED ON MAY 23, 1934.

Effect of Method of Cultivation on Soil Moisture, Nitrates, and Temperature

Moisture was determined weekly in the row between plants in both the first and second 6 inches of surface soil. The nitrates were determined biweekly only in the first 6 inches of soil. The nitrate formation is probably closely associated with aeration. If this is true then the looser soil of a ridge should be more conducive to nitrification than the more compact soil of level culture. Table 1 shows the seasonal trends in soil moisture and nitrates in gravelly sandy loam typical of nearly ideal potato soil in New York State.

Table 1.—*Moisture and nitrates in gravelly sandy loam soil*—1934.

Treatment	Period*	Per Cent Moisture on Moist-Weight Basis			P.P.M. No.3
		First 6" Soil	Second 6" Soil	First 12" Soil	First 6" Soil
			Irrigated		
Level	Before tuber set	9.14	10.18	9.66	79
	After tuber set	11.94	12.03	11.99	6
	Season	11.18	11.52	11.35	30
Four inch ridge	Before tuber set	8.13	11.01	9.57	109
	After tuber set	11.06	12.07	11.57	7
	Season	10.26	11.78	11.02	41
Seven inch ridge	Before tuber set	8.54	11.52	10.03	101
	After tuber set	11.48	12.55	11.97	9
	Season	10.68	12.27	11.48	40
			Not irrigated		
Level	Before tuber set	9.16	10.42	9.79	97
	After tuber set	10.10	10.59	10.35	13
	Season	9.84	10.54	10.19	41
Four inch ridge	Before tuber set	8.37	11.22	9.80	128
	After tuber set	8.72	10.11	9.42	30
	Season	8.63	10.41	9.52	63
Seven inch ridge	Before tuber set	8.19	11.53	9.86	141
	After tuber set	8.26	9.65	8.96	38
	Season	8.24	10.16	9.20	72

*Period before tuber set—four weeks
Period after tuber set—eight weeks
Season average weighted

Overhead irrigation was given whenever needed, providing the air was still enough to permit even application. When compared with the same culture treatments with only natural rainfall, it may be seen that sufficient irrigation water was applied to eliminate moisture differences among the various treatments. Without irrigation the soil moisture decreased with increasing height of ridge, especially noticeable after

tuber set, when available moisture is undoubtedly closely correlated with the yield.

Differences in soil moisture among the same treatments were in the same direction but less marked on silty clay loam soil. This proved true for the fallow plots also.

The higher nitrates found in ridge culture might be expected to favor a prolonged top growth at the expense of tuber formation. High nitrates may also be detrimental to cooking quality. Werner (5) has shown that potatoes grown in soil having high nitrates had a high protein content. This made the cooking quality inferior to potatoes with lower protein and higher starch content. From this cultivation experiment no tubers were analyzed and cooked in order to contribute evidence on this point.

Soil temperature at the level of the seed piece was nearly 1° F. lower in level culture than where ridges were employed. The greatest daily range is found in ridges,—in other words, temperature where tubers form is most uniform with level culture. Gilmore (2) has suggested that this may be an important influence on culinary quality of tubers. The claim is almost universal that potatoes of the best quality are produced where the temperature is most uniform. Bushnell (1) has shown that yields may markedly decrease with increase in temperature above 18° to 20° C.

Effect of Method of Culture on Root Distribution

Potato roots are confined very largely to the first two feet of soil and particularly to the depth plowed. Normally these roots fully occupy the entire furrow slice and when undisturbed grow within one half inch of the soil surface. This holds true in both ridge and level culture. However, there is a tendency toward fewer roots midway between the ridged rows. They are branched three to four times, and are very fibrous, this being particularly noticeable in ridge culture where aeration is best. Aeration is essential and, of course, is most limited in subsoil. When roots are injured, branching and replacement are very rapid but can be only at the expense of growth elsewhere in the plant. The three to six branches usually emanate within an inch of the end of the pruned root. Very often these branches continue in the same direction as the original root, some may take a downward trend, but it is impossible to say that any definite direction of growth will be taken by branches of this type. Pruning certainly does not *force* them to grow downward.

It is a popular belief that cultivation for the purpose of pruning the side roots is a good practice since it is thought that the remaining undisturbed and more vertical roots will be forced to go deeper "in search of water." Actual observations and measurements show this idea to be erroneous in that roots remaining on root pruned plants do not penetrate to so great a depth as roots from the normal undisturbed plants. This fact was revealed after excavating a trench at right angles to the direction of the rows and then working upwards under the plant by the use of an ice pick and small hand weeder. The first roots so encountered were measured and found to be 27 inches below the surface on plants where side roots had been pruned compared with an average of 33 inches for the deepest roots on plants growing in undisturbed soil. This maximum depth below the surface is approximately the same whether under ridge or level culture. Cultivation also limits the roots in the surface soil to that area below the deepest cultivator tooth, usually 4 inches at least, and within 3 to 4 inches from either side of the plant where the soil is not disturbed. This may account for the good response to row application of fertilizer as compared to the response obtained with the same amount of fertilizer broadcast but confined to the surface soil in which few or no roots are permitted to grow.

To study the seriousness of root pruning, such as accompanies ordinary cultivation, 4 rows of potatoes were planted 4 inches deep and covered level with the initial soil surface. The soil was not disturbed throughout the growing season, the weeds being removed by scraping with a hoe. On two rows, beginning when the plants were four inches tall and continuing once each week for 4 consecutive weeks, the roots were cut about 4 inches on either side of the row and 4 inches deep by inserting a spade so as to approximate the pruning action only of a cultivator tooth. The remaining two rows were allowed to grow normally with no root pruning. No other difference in treatment existed between the two pairs of rows. The foregoing root penetration measurements were made on these treatments. In addition, the roots occurring in the surface soil of each treatment were displayed by washing off three inches of the surface soil with water. After photographing, the roots so exposed were removed and the horizon of soil between 3 and 5 inches below the surface was similarly washed. Figures 2 and 3 show the root distribution found at this depth.

It is very apparent that the plants in the latter photograph could not and did not make use of the surface 5 inches of soil. The same plants reached a maximum depth of 27 inches or a horizon of about 22 inches from which to get water and nutrients compared with 33 inches for normal plants where the roots remained undisturbed.

FIGURE 2.—ROOT DISTRIBUTION 95 DAYS AFTER PLANTING

These roots had not been pruned, and were from three to five inches below the soil surface

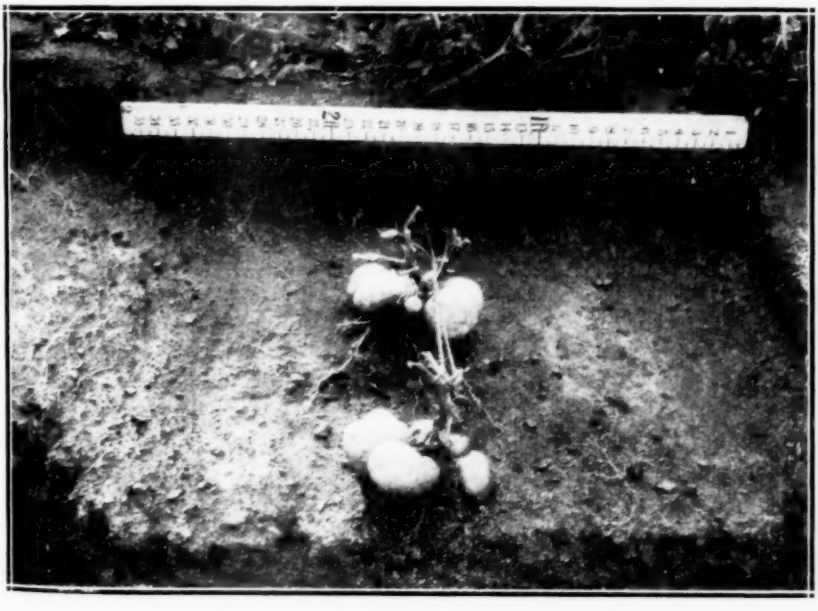

FIGURE 3.—ROOT DISTRIBUTION 95 DAYS AFTER PLANTING

These roots had been pruned, and were from three to five inches below the soil surface. Compare with Figure 2.

Effect of Treatment on Yield

To single out any one factor, under field conditions, in order to study its effect on yield is almost impossible. Various methods of culture change several factors simultaneously. For instance, if the soil becomes drier, then it may become warmer and better aerated. All these factors may influence growth of plants. The yield is the best, at least the most practical, single expression of all these factors. In the following tables the No. 1 yield represents all tubers 1⅞ inches or larger.

Table 2.—*Effect of root pruning on growth of Smooth Rural potatoes and on ridge culture*

Treatment		Yield in Bushels per Acre		
Planting depth	Covering above Seed Piece	Irrigated	Not Irrigated	Difference in Favor of Irrigated Plots
		Total Yield		
Four inches	Four inches (level)	424.0	386.3	37.7
One inch	Four inches (ridge)	413.9	345.0	68.9
One inch	Seven inches (ridge)	425.7	336.6	89.1
		No. 1 Yield		
Four inches	Four inches (level)	406.6	363.0	43.6
One inch	Four inches (ridge)	403.6	325.9	77.7
One inch	Seven inches (ridge)	417.9	325.7	92.2

All the above differences are highly significant mathematically.

Cultural Methods

Table 2 shows that without irrigation yields very definitely decrease as the height of ridge increases. The addition of irrigation water eliminated these differences in favor of level culture. The difference in favor of all irrigated plots indicates that moisture was a limiting factor to yield, becoming greater as the height of ridge increased. These yields are very highly correlated with the moisture content of the soil given in table 1. On the heavier soils these differ-

ences are not so marked but are in the same relation to method of culture.

Moore (3) has shown that sunburning decreases by ridging, but there is no marked influence on other physiological defects such as growth cracks and second growth. There is a tendency toward a smaller number of tubers in ridge culture. Their shape is not influenced by ridging.

Root Pruning

Table 3 shows the effect of root pruning alone on yield of tops and tubers.

These yields are directly related to the root systems shown in figures 2 and 3.

Table 3—*Effect of root pruning on growth of Smooth Rural potatoes on a sandy loam soil*—1934.

Treatment	Fresh Weight per Top Ounces	No. Tubers per Plant	Yield Tubers			
			Total		No. 1	
			Ounces per Plant	Bushels per Acre	Ounces per Plant	Bushels per Acre
I. Planted 4 inches deep —weeds removed by scraping — no cultivation	16.6	6.8	32.4	490.1	31.0	468.9
II. Same as I, except roots pruned	10.9	6.5	26.9	406.9	25.4	384.2
Difference	5.7	0.3	5.5	83.2	5.6	84.7

All differences except number of tubers per plant are mathematically significant.

Nitrates

No difference in yield was obtained when nitrates in the soil were kept high during tuber formation. This was accomplished by adding 320 pounds of nitrate of soda to the acre after tuber set for one year only on all 3 types of culture. There is no indication that the nitrates accompanying the ridge methods of cultivation are detrimental to yield.

Summary and Conclusions

This study indicates that:

1. Deep planting with shallow covering hastens the emergence by as much as one week compared with shallow planting and deep covering (ridging). The former method should aid in reducing ravages from rhizoctonia and in weed control.
2. The primary benefit from cultivation is weed control. It should cease entirely when the plants reach the blossom stage or when they nearly cover the surface between the rows.
3. A broad sweep weeder is the most efficient tool for early cultivation. It should be used exclusively until the plants reach a height of 8 to 10 inches. It will result in a maximum of weed destruction and a minimum of root pruning.
4. Soil moisture is probably the most important factor influencing yields. In the surface 12 inches of soil it decreases with increasing height of ridge. The differences are greatest when moisture is most needed. Lower soil moisture, higher soil nitrates and higher soil temperature are soil conditions found in ridges that are unfavorable to high yields of potatoes but may be favorable to scab growth.
5. Root pruning by cultivation may nullify all the environmental conditions otherwise in favor of level culture.
6. In situations where ridging is necessary, it should be moderate, completed early in the life of the plant and remain undisturbed thereafter. At each successive cultivation, the cultivator should be narrowed, allowing the ridge to become broader and flattened on top. On sloping land these ridged rows may actually conserve water which would otherwise run off, but they must be on the contour to do so.

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POTATO CONSUMPTION AND DIETETIC VALUE[1, 2]

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A worth-while treatment of the subjects comprehended in the title of this report requires that each be treated under a separate heading. Potato consumption *per se* might well be considered in several phases such as *per capita* use as food, seed, loss from diseases in field and storage, storage shrinkage, use as feed for livestock, processed potatoes, waste in handling and marketing and various industrial uses. Reliable statistics which would account for total potato crop disappearance are not as yet available in the United States. More complete state and federal census figures and thorough-going collaboration between the states and federal government are necessary to make our knowledge of this subject at all adequate. At present data on potato consumption in foreign countries available through the Foreign Agricultural Service Division of the U. S. Department of Agriculture are much more complete than for our own country. In this report the consumption of potatoes as food only will be treated and very briefly, because of lack of available information.

POTATO CONSUMPTION

Some idea of potato consumption in European countries may be gained from data supplied by the Foreign Agricultural Service Division of the U. S. Department of Agriculture as shown in table 1.

Of the high *per capita* consumption reported for Germany, 21.13 bushels, or 30.3 per cent is used for food. This means a *per capita* food consumption of approximately 6.4 bushels, more than double that of the United States. Figures available from Germany indicate that consumption is more than 60 per cent higher among the rural than among the urban populations. Likewise, consumption by the middle and the laboring classes is about double that of the higher classes.

Stuart (9) in his book "The Potato" states that of our annual *per capita* production of approximately 3½ bushels we eat 2 1/3

[1]Partial Report of Research Committee of Potato Association of America.
[2]Presented as paper No. 159, Department of Vegetable Crops, Cornell University, Ithaca, New York.
[3]Chairman of Committee including also H. H. Bakken of the University of Wisconsin, and C. H. Metzger of Colorado State College of Agriculture.

TABLE 1. *Per capita consumption of potatoes for all purposes in specified European countries,—average* 1921-1925

Country	Per Capita Consumption
	(bushels)
United Kingdom	4.76
Norway	9.59
Sweden	10.83
Denmark	12.74
Germany	21.13
France	11.45
Belgium	14.37
Netherlands	13.16
Austria	8.58
Hungary	7.20
Italy	1.53

Compiled in Foreign Agricultural Service Division.

bushels. Hardenburg (5) in a survey of 114 city families and 173 farm families in New York obtained an average of 3.95 and 8.7 bushels *per capita* respectively. This survey was made in 1928-1929 when the crop was large and the price very low. Compared with 1925 when the crop was short and the price more than three times as high, *per capita* consumption in the 35 late potato states was noticeably lower. Rinear (7) made a house-to-house canvass in 1929 of 1052 homes (4536 people) in six New Hampshire cities and towns to study consumer preference for potatoes. He reported a consumption of 3.28 bushels *per capita* with consumption decreasing as family income increased. Only 26 per cent of these people claimed to eat fewer potatoes as the price increased whereas 74 per cent stated that the price made no difference. By nationality, *per capita* consumption was for Polish 3.87, German 3.66, Irish 3.32, American 3.28, Hebrew 3.18, French 3.17 and Italian 3.17 bushels. Bakken (2) in a similar study, made in 1934 in Milwaukee, Madison and Chicago found a *per capita* consumption of 2 1/3 bushels.

Dietetic Value

The term dietetic as used in this report is assumed to include such considerations as nutritive value, digestibility, health-giving properties and composition. Culinary quality is discussed in a separate committee report. The dietetic value of the potato has been recognized in our literature almost since its commercial production began. Recently Archbold (1) compiled a very extensive bibliography of eighty-two references on the potato as an article of diet. (The reader is referred to this work published in 1935 by the Potato Marketing Board, London).

Canon (3), reporting in 1915, may be quoted as follows: "It has been shown from the data of fifteen American dietary studies representative of ordinary food habits that potatoes represent 3.9 per cent of the total cost of food and that they furnish 5.3 per cent of the total calories, 4.2 per cent of the total protein, 8.7 per cent of the total phosphorus and 13.5 per cent of the total iron". As to the digestibility of potatoes Canon stated that experiments have shown that 68 to 73 per cent of the protein and 92 to 99 per cent of the carbohydrate of potatoes is digested by the average person. She further pointed out the fact that although the potato is essentially a starchy food, it possesses other attributes known to be essential in a food of high dietetic value. These attributes, which rate the potato very high, are that it gives bulk, supplies the essential minerals, phosphorus, iron and potassium in liberal quantity, neutralizes body acids and provides certain health-promoting vitamins. Goldthwaite (4) in 1925 stated that chemical analysis of the ash of the potato shows it contains calcium, magnesium, potassium, sodium, phosphorus, chlorine, sulphur and iron. This potassium and sodium are especially valuable in making the potato a base-forming food which neutralizes the acid reaction resulting from such common foods as meat, eggs, fats and cereals. She further pointed out that vitamins B and C are found in moderate quantities in both boiled and baked potatoes and, whereas vitamin B occurs in greater quantites than C, the latter is sufficient to render the potato of value as an antiscorbutic food. Goldthwaite indicated that the potato contained less vitamin C than oranges, lemons and tomatoes. Since then Tressler (10) of the Geneva Experiment Station has shown that the potato is just as rich in C as is tomato juice. Richardson (6) in 1929 reported that the potato is rich in iron, sulfur, phosphorus, potash and sodium, the potash and sodium being especially effective in overcoming acidosis. Richardson stated that among the essential

minerals, potatoes are deficient only in calcium which can be supplemented economically by the use of milk. Regarding vitamins, B and C are in ample supply whereas vitamin A is deficient. She recommended quick cooking since long cooking tends to destroy vitamin C. Stiebeling (8), in 1932, published a table comparing the iron content of a long list of fruits and vegetables. Based on the fresh weight basis all of these commodities were classified into four groups according to whether or not their iron content is poor, fair, good or excellent. Old potatoes are classed as having good iron content whereas new stock is classed as only fair. On this basis old tubers contain 0.0008 to 0.00159 whereas new potatoes contain only 0.0004 to 0.00079 per cent of iron.

It is well known that potatoes are essentially a carbohydrate food and as such have a high caloric value. The U. S. Department of Agriculture in 1936 (11) reported that potatoes furnish three hundred and eighty-five calories to the pound of fresh weight. This figure checks closely with that reported by other workers.

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THE SIGNIFICANCE OF PRE-EMERGENCE SOIL MOISTURE TO YIELD OF POTATOES ON DRY LAND IN THE WESTERN HIGH PLAINS AREA

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In the high plains area of western Nebraska where potatoes are grown as a dry land crop, the total annual rainfall ranges from ten to twenty inches. Generally only one-half or two-thirds of this rainfall can be caught and held in the soil for the use of the plants. The balance occurs either as small showers that soon evaporate or in heavy downpours when much runs off the surface. The useful rainfall during the growing season for potatoes (July 1 to September 30) is rarely more than six and frequently less than three inches.

Data secured during the last five years from potato plats in the crop rotation fields at the Box Butte (Nebraska) Experimental Farm are of interest in showing the response of the potato crop to pre-emergence and summer rainfall and its ability to produce a crop from stored moisture. Data from three series of each of a number of crop rotation sequences are available but for the sake of simplicity and because of similarity those from only one series of three rotations are considered.[3]

Soil moisture data were secured on the various dates from four holes made with a steel tube in each of the 1/10th acre plats. Samples were generally secured at intervals of two weeks or as soon as possible after any effective rain. All soil samples from each foot of each plat were saved and the hygroscopic coefficient was determined by the usual procedure from each of these composite samples. For the purposes of this paper all moisture in excess of the hygroscopic coefficient is considered as being available to the plants. Total field moisture capacity is assumed to be two and one-half times the hygroscopic coefficient and the available moisture capacity is the difference between the total field capacity and the hydroscopic coefficient. It does not include free water but only the water the soil can hold against gravity. Sometimes the term "total wetness" is used to designate a

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[2]The author is indebted to Philip Hoff, John McLean, W. A. Allington, Geo. Schmid and M. Afanasiev for assistance in soil moisture sampling and to John Pospisil and Geo. Schmid for the care of the crops in the various rotations.

[3]More data concerning these rotations prior to 1936 are reported: Werner, H. O.—The relation of rainfall distribution, soil moisture and crop rotation to the yield of potatoes at the Box Butte Experimental farm. 1936. 17th Ann. Rept. Nebraska Potato Improvement Assoc. pp. 39-55.

soil filled to this extent. The soil used was Rosebud very fine sandy loam which has a relatively low moisture holding capacity with hygroscopic coefficients ranging from 4.3 to 9.4 but generally between 6.5 and 7.5 per cent. Because of this low moisture holding capacity percentage figures for soil moisture have been converted into inches by assuming that each 7 per cent of soil moisture is equal to one inch of water. Total rainfall is not used because much of it occurs in showers too small to be of use to plants. Effective rainfall is calculated as all precipitation of 0.25 inch or more occurring in one day or two consecutive days. Of course this moisture is effective only if absorbed by the soil. It does not consider losses by evaporation or run off. Therefore the amount of moisture that actually gets into the soil so that plants can use it is still less than that designated as effective rainfall. Preëmergence rainfall is figured as all effective precipitation from the previous Oct. 1 to June 30 which is about the time plants emerge from plantings made between June 15 and 20, the customary planting period.

During each of the five years considered preëmergence precipitation was very useful for satisfactory potato crop production, and was practically indispensable in four of the five years (table 1). In three of the five years, 1932, 1934, 1936, it was definitely necessary to get several inches of this preëmergence moisture into the upper five

TABLE 1.—*Effective rainfall prior to and during several crop seasons, together with calculated available moisture in upper five feet at plant emergence time and yield of potatoes in three five-year rotations*

Crop Year	Inches of Effective Rainfall		Inches of Available Moisture Stored in Top 5 Ft. after Crops Specified			Total Yield of Potatoes in Bushels per Acre after Crops Specified		
	Oct. 1 to June 30	July 1 to Sept. 30	Small Grain	Corn	Summer Fallow	Small Grain	Corn	Summer Fallow
1932	6.94	4.38	(Not obtained)			18	78	139
1933	9.85	4.97	3.8	5.0	5.0	139	153	166
1934	5.84	0.52	2.3	4.6	6.3	5	22	81
1935	12.35	1.44	6.2	6.6	6.8	131	103	121
1936	6.94	1.22	1.1	5.0	6.4	5	30	63

feet of soil prior to the first of October of the previous year, if good yields were to be secured.

During these five years the crops of 1933 and 1935 were good, that of 1932 was fair and those of 1934 and 1936 were very poor, being failures in many plats (table 1). The crop of 1933 was produced

on a fairly good supply, not maximum, of preëmergence precipitation supplemented by almost five inches of summer rainfall. The 1935 crop was grown almost entirely on preëmergence moisture, the 1.44 inches of summer rainfall having come in three small widely separated showers that were of little value. The crop of 1932 emerged when only an average amount of moisture was in the soil and consequently this crop was poor except where there was a carry-over from the previous crop as after corn or summer fallow. Without a good carry-over of soil moisture the summer rain of 4.4 inches was inadequate, largely because three-fourths of it came after the middle of August, by which time plants in plats after small grain had been too severely damaged to be able to respond. The seasons of 1934 and 1936 were the worst drought years on record and all crops were failures except where there was a carry-over of moisture from the previous season. The great value of preëmergence moisture was strikingly shown in 1935. During that summer the weather was practically as dry as in 1936, but the stored moisture was almost twice as great and good yields naturally resulted. In all of these five years summer rainfall alone was inadequate to bring about satisfactory yields if there was a soil moisture deficit at emergence time.

In seasons of low rainfall good potato crops have been produced following summer fallow, fair to good crops after corn, and uniformly poor crops after small grain. During seasons of this nature the amount of available moisture stored in the top five feet of soil in plats following small grain, was very small, very much greater following corn; and slightly greater following summer fallow (table 2). Small grain exhausted the moisture in each of the top five feet to a much greater extent than did corn. The soil moisture conditions at emergence time in 1936 illustrates this very distinctly. In the spring of 1935 the soil in all plats was filled to a great depth by copious spring rains, but in plats where a small grain crop was grown in 1935 available moisture was removed to so great an extent that by early July in 1936 there was only a very small amount of available moisture in the top foot, a little in the second foot and practically none in the third to fifth feet (table 2). Following corn there was still considerable moisture in the top three feet and very little had been removed from the fourth and fifth feet. After summer fallow there was still more moisture in the top two feet, and the lower three feet were practically filled to their field capacity. Probably most of the moisture in 1936 below the top foot was in the soil prior to October, 1935, since more than half of the preëmergence precipitation of 1936 (calculated as 6.94") came as snow that blew off, or as light, scattered spring rains that

TABLE 2.—*Calculated available moisture (as inches) found in early July in two typical seasons in each of the top 5 feet of soil in potato fields following small grain, corn and summer fallow in five-year rotations*

Depth of Soil (feet)	1935			1936		
	Previous Crop			Previous Crop		
	Small Grain	Corn	Summer Fallow	Small Grain	Corn	Summer Fallow
1	1.31	1.53	1.33	.49	0.63	.91
2	1.11	0.96	0.89	.31	0.94	.88
3	1.10	1.30	1.16	0	0.81	1.59
4	1.39	1.57	1.84	.19	1.14	1.64
5	1.24	1.27	1.61	.06	1.47	1.34
Total	6.15	6.63	6.83	1.05	4.99	6.36

evaporated. The other half of the rainfall which fell in June was dissipated, to a considerable degree, by evaporation in the course of soil preparation and planting, and during the excessively hot dry weather late in that month. The moisture found in the field following small grain apparently indicates that less than 1 inch of this 6.94 inches of preplanting precipitation was available for use by the plants after they reached the soil surface in early July in 1936. In 1935 the spring rainfall was so great that practically all soil moisture differences as a result of previous crops were wiped out. Soil moisture data acquired in 1933 and 1934 are very similar to those of 1936 in that there was a deficiency in moisture to a depth of five feet after small grain, to two or three feet following corn and little or no deficiency following fallow except in spots where weeds had become established for brief periods.

The ability of the potato plant to make a fair crop on stored moisture with little or no rainfall on the growing crop is very clearly shown by the reasonably satisfactory yields secured after summer fallow and the slightly lower yields following corn in 1932, 1934 and 1936. In 1935 the higher yields after small grain are believed to have been caused by the loss of surface soil from corn and fallow plats by blowing during the very dry windy winter and by the accumulation of soil from blowing in grain stubble. There was much indication that the nitrate supply in this drift soil was an important factor in stimulating early growth after small grain.

The behavior of the potato plant regarding its ability to remove moisture from the soil was very clearly observed in the seasons of

1934, 1935 and 1936 as there was little rain after the plants emerged. In the plat following summer fallow, which was quite well filled with moisture at planting time, most of the moisture for the July growth was taken out the top two feet as is shown for 1935 in table 3. During early August there was very little moisture available in the top two feet and the plant drew most of its supply from the 3rd and 4th feet. In 1935 there was serious depletion into the fifth foot by the 23rd of August. During the latter part of August and during September more moisture was drawn from the fourth and fifth feet, and the top three feet were depleted of still more moisture, it being reduced to the hygroscopic coefficient. Therefore by harvest time the potato plants had succeeded in removing most of the available water from the top five feet of soil. In so doing a reasonably good tuber crop was produced but it left no reserve moisture for an ensuing grain crop. This moisture in the fourth or fifth foot of a potato field was of great importance in several instances. It enabled the plants to live through a drought period in August so as to be alive to utilize fall rains and therefore be in a position to produce tubers during the cool short September days that are very favorable for tuber formation.

TABLE 3.—*Removal of available moisture in the upper 5 feet of a potato plat following summer fallow during the almost rainless*[1] *crop season of* 1935

Depth (feet)	Hygroscopic Coefficient from Composite Samples	Percentage of Available Moisture on Sampling Date					
		June 21	July 6	July 22	Aug. 23	Sept. 2	Oct. 15
1	6.3	11.0	9.3	4.3	—0.5	2.6	—0.2
2	8.0		6.2	6.8	—0.7	2.2	—0.2
3	7.6		8.1	8.9	0.1	2.1	0.9
4	9.4		12.9		4.0		1.4
5	9.8		12.3		5.2		5.9

Depletion of soil moisture near the surface was less complete when some moisture was available in the third and lower feet than when there was no deep subsoil moisture.

In view of the information secured on the Box Butte Experimental Farm concerning the significance of soil moisture, soil samples were taken to a depth of three or four feet in eighteen dry land fields in northwestern Nebraska during the last few days of June in 1936. The fields selected were on the farms where growers used certified seed

[1]Only rains of consequence after planting were: July 7, 0.52"; Sept. 1, 0.54"; Sept. 7-8, 0.38".

potatoes and were scattered over a region about fifty miles square. At all of these places the rainfall from planting time until harvest amounted to less than 0.75 inches and practically none of this was of any value to the plants.

TABLE 4.—*Soil moisture just after planting time and yield of potatoes following various crops as found in 18 fields in western Nebraska in 1936*

Previous Crop	Number of Fields	Available Moisture in Upper 3 Feet	Total Average Yield per Acre
Sweet clover	1	1.3 inches	5.0 bu.
Small grain	12	1.6	10.7
Corn	3	2.6	20.6
Summer fallow	2	4.2	71.6

The moisture in the top three feet of the twelve fields that had been planted with small grain in 1935 averaged 1.3 inches ranging from a high of 3.2 inches to a low of 0.8 inch (table 4). The total yields of potatoes averaged only 10.7 bushels ranging from 0 to 20 bushels. The yields were quite closely proportional to stored moisture. Following corn the soil moisture content was almost twice as great as following small grain and the yield was also almost twice as great. The two fields that followed summer fallow had 3.9 and 4.4 inches of available moisture in the top three feet with an additional inch or two in the fourth and fifth feet. These fields yielded 63 and 80 bushels of potatoes to the acre. There was about an inch of moisture in the fourth foot of soil in fields following corn, but after a crop of sweet clover or small grain there was never more than 0.2 inch of available moisture in the fourth foot.

CONCLUSIONS

In the high plains area in western Nebraska precipitation, occurring prior to planting time, or at least prior to emergence, of main season plantings of potatoes has been a more significant factor in the production of satisfactory yields than the rainfall during the crop season. Very satisfactory yields of potatoes have been produced with only the moisture stored in the soil prior to the emergence of the potato plants. In years of low rainfall the potato crops have practically been failures when planted after small grain, because of the serious depletion of soil moisture as deep as the fifth foot. Potato yields following corn have been fairly good since this crop removed very little mois-

ture below the third foot. The best potato yields have been obtained following summer fallow. During summers of little rainfall, the potatoes removed practically all available moisture from the upper five feet of soil.

SECTIONAL NOTES

California

At the present time the Kern County district has shipped by rail and truck an estimated shipment of 7,800 cars. It is estimated that 6,000 cars are left in the district. However, this quantity is subject to the rate of digging, as the potatoes under the vines that are still green are increasing in size. It is entirely possible that the remaining fields will produce 8,000 or 9,000 cars instead of 6,000.

This year the highest known yields have been 350 sacks of potatoes to the acre. Last year there were many fields which yielded more than 400 sacks to the acre. This would indicate a somewhat smaller crop than last year. There has been a widespread outlet throughout the United States for Kern County potatoes, and at present it looks as though this district will market so many potatoes during the month of June that they will have been successful in disposing of the output of the 20,000 or 23,000 acres that were planted.

There is a small increase in acreage in Southern California which can be used during July if the above-predicted conditions in Kern County still prevail. There has been no increase in the Stockton district and the production will be normal for this section.

Planting is just being completed in the Klamath Basin, which is partly in California and partly in Oregon. Last year the acreage in this district was 16,100 acres and this year it is estimated at 17,400 acres. The potatoes in this area were planted under good conditions and so far everything has been normal. (June 9).—H. G. Zuckerman.

Florida

Every year, at some time during the growing season, weather conditions become especially favorable for the development of potato diseases in one or more of the potato-growing sections of Florida. Such conditions existed at Hastings in 1937 when the seed-borne diseases including late blight, the new bacterial wilt and soft rot described by Bonde of Maine and Baribeau of Canada, and black leg, caused a loss estimated at one million dollars.

Despite the good care which the seed received after its arrival in Florida and the regular application of copper-lime dust to the growing

crop, the stands were reduced from 10 to 60 per cent in hundreds of acres planted with certified seed severely infected with late blight which rotted the seed pieces, killed the sprouts and plants, and caused a high percentage of tuber decay.

The wet weather during the first half of April also favored the development of black leg, the bacterial wilt, and soft rot which ruined the marketability of thousands of barrels of potatoes harvested from fields where these diseases were present.

The loss resulting from planting certified seed which carried high percentages of late blight, bacterial wilt, soft rot, and black leg proved that such seed was unfit for planting and that the present certification requirements do not insure the delivery of seed which will produce potato crops reasonably free from late blight, soft rot and black leg under conditions similar to those which existed at Hastings in 1937.

At a recent meeting of potato growers at Orlando, Florida, the question of seed certification was discussed and a committee was appointed to draw up a resolution which was adopted by the growers in attendance.

Resolution

WHEREAS, the Florida potato growers for years have been having great trouble in their potato production, due to much disease being brought from other States and spread by the purchasing of this unfit and diseased potato seed, despite the certification requirements of the various seed producing States and Countries. The Florida growers find the certification requirements of these states and countries either vary greatly or apparently are sometimes very poorly enforced.

THEREFORE, be it resolved that, the U. S. Department of Agriculture make a study of potato seed certification now in effect in various States, and after having made such a study, we, the Florida Potato Growers, recommend and urge the setting up of a very rigid Federal potato seed certification law to be operated, maintained, and enforced as a Federal Potato Seed Certification Service. (June 11).—A. H. EDDINS.

Committee—

L. L. CHANDLER, Goulds, Fla.
C. H. WARNER, Secy. Bunnell Potato Growers' Association, Bunnell, Fla.
G. W. LEE, Manager, Hastings Potato Growers' Association, Hastings, Fla.
A. H. EDDINS, Pathologist, Florida Experiment Station, Hastings, Fla.

Indiana

Early potatoes, especially the Cobblers, look very fine. The stands are good, foliage is healthy, and from numerous plants examined it looks as though we are going to have a good yield. The potatoes are about 1¾ inches in size now in southern and central Indiana. Triumphs are showing some damage from the leafhopper as the wet spring delayed the application of control measures.

The late crop is now being planted, mostly Cobblers, Rurals, and a few Katahdins. Recent rains and cooler weather have been beneficial to the early crop, and the rains have aided in getting the ground in good condition for the late planting. (June 7).—W. B. Ward.

Maine

Growers are practically through planting at this time. Cultivating operations are progressing. The potatoes on the earlier planted fields are now coming through the ground. The unfavorable weather conditions this season have delayed planting operations considerably. The potatoes that are now germinating have a thrifty appearance and there does not seem to be a great deal of decayed seed resulting from the wet weather.

Acreage intentions released by the United States Department of Agriculture have indicated approximately six per cent increase. It is quite a general consensus of opinion, however, that very little, if any, increase has materialized, largely because of unfavorable weather during the planting period. The amount of fertilizer applied, however, has increased to a certain extent. Growers are spacing seed closer together and increasing the rate of fertilizer. This practice has developed more particularly among the seed potato growers but has spread to table stock producers as well.

A recent ruling of the State Department of Agriculture to go into effect next shipping season limiting the size of seed to twelve ounces has aroused considerable interest. This should result in more uniform sized seed and should give greater satisfaction to the consumer.

The State Department of Agriculture sponsored Trade Marking and Packaging shows have started this week with great interest on the part of commercial organizations and growers. This is one feature of the advertising program for Maine potatoes. Growers are becoming more and more conscious of their responsibility in developing marketing methods and facilities to serve themselves.

Plans are now being made in preparation for next season on the industry tax of one cent for each barrel which goes into effect to assist

in merchandising the Maine potato crop. This should be productive of some very beneficial results. (June 15).—FRANK W. HUSSEY.

MARYLAND

Potato planting was completed during the latter part of May in the western Maryland area where the elevation is more than 1,000 feet above sea level. On account of rain, planting was delayed from one week to ten days. More than one-half of the acreage in this area was planted to Smooth Rurals. Russet Rurals were also extensively planted. Small plantings were made with the Irish Cobbler, Warba, Katahdin, Green Mountain and Chippewa varieties. It is estimated that the acreage will be a little larger than it was last year.

The Eastern Shore potato area was visited during the week of June 7. Nearly all the potato fields were in bloom at that time and appeared to be in excellent condition. Not many diseases were observed and the stands were good. (June 12).—R. A. JEHLE.

MASSACHUSETTS

An unusually long period of wet weather has prevailed to the present period. On heavy ground, some seed rot has occurred and this has been unusually severe on several hundred acres of the potato crop flooded by the Connecticut River after planting. Except for some rot on the heavier ground, most of the potato acreage is progressing favorably, although it is somewhat later because of the continued wet weather.

The acreage appears to be slightly increased above that of last year. The estimates indicate that there may possibly be an increase up to ten per cent.

Flea beetles are quite prevalent and the better growers have started spraying somewhat earlier than usual in an attempt to control them. In general, the potato crop is progressing favorably. (June 14).—RALPH W. DONALDSON.

NEBRASKA

Planting of the late crop of potatoes began on a small scale during the first week in June, in the North Platte Valley, and was at its peak by the 10th of June. Normally the period of greatest activity in planting late potatoes in this section occurs about the 15th of June. However, as a result of the poor stands obtained from late-planted potatoes last year, the late crop is being planted somewhat earlier. At the present time soil moisture is very satisfactory for planting potatoes. Whether or not the somewhat earlier plantings this year will be successful, will be determined by the extent to which the potatoes suffer from wilt, and purple

top later in the season The earlier plantings in the past have always been more seriously affected by these diseases, than plantings made about the 15th of June. A larger acreage of late potatoes is being planted this year than last year. However, it is difficult to determine the exact acreage at this time, as the planting season has not yet drawn to a close.

The early crop of potatoes in the North Platte Valley has been emerging since approximately the first of June. During the 4th and 5th of June, temperatures in this area dropped to 33 and 34 degrees. A strong wind accompanied the low temperatures and some of the early potatoes which had germinated at that time were slightly damaged. However, it is believed that the damage was not at all serious. We have made examinations of some of the early potatoes for psyllid, but none has been located to date. A few plants have been observed to be affected with the hay wire disease. The present prospects for good crops of both early and late potatoes are very favorable. (June 11).—LIONEL HARRIS.

For the first time in more than a year, the Nebraska potato situation is hopeful. During the season of 1936, the outlook was not bright at any time, and it seems miraculous that anything was produced. The results have been noted before, that about half of the dry-land crop was not dug, and much of the remainder merely returned the seed planted. It was, without a doubt, the most disastrous season ever experienced in Nebraska.

Beginning about the first of June, most of western Nebraska was favored by generous rains, therefore the situation from practically no soil moisture was changed to one in which it should be possible to produce good stands. By careful handling of the soil it should be possible to subsist about a month before rains will be needed. In contrast with a year ago, the weather tends to be cool, therefore further favoring the planting of potatoes. During 1936, temperatures were in the neighborhood of 105 to 110° F. even before the first of June, and continued without abatement until the latter part of August.

Heavy planting of the late crop was in progress before the 10th of June which is somewhat earlier than usual. The acreage planted indicates material curtailment of acreage in dry-land areas. It is estimated that not more than 60 per cent of last year's acreage will be planted on dry-land this year. In the case of the acreage entered for certification, the situation is somewhat better, as probably 75 per cent will be planted.

The irrigated sections, having had a very successful crop in 1936, will increase their commercial plantings 10 to 15 per cent, and the certified plantings will be increased to a somewhat larger extent. This increase in planting is decreasing the sugar beet acreage, thus displacing another crop.

Since the advent of rains, it should be noted that the mental condition of growers, as well as townspeople has taken a decided change for the better. Instead of turning the land back to the Indians, and moving out of the country, as was threatened, most people have decided to stay and try it again. (June 16).—MARX KOEHNKE.

NEW YORK

The month of May showed an abnormally high precipitation over many of the potato growing sections of our state. This stormy period naturally caused some delay in planting. For those who were fortunate enough to complete their planting operations, growing conditions have been excellent. Many acres in the counties bordering the lakes are yet to be planted (as of June 10th). The conditions on Long Island are reported to be favorable, and therefore the crop was planted at the proper time.

The potato acreage estimate for New York is not yet available. Apparently more than the usual amount of second class seed was planted, because the market for certified seed continued very draggy even at planting time.

The 8th Annual Summer Field Day of the Empire State Potato Club will be held on the farm of Bruce Cottrell of Homer in Cortland County. The date, not yet definite, will probably be the 5th of August. Demonstration plots have been planted by several departments of the College on the Cottrell farm. The attendance should be large, as Cottrell is one of the most successful seed growers in New York. He grows about 80 acres of Green Mountains and Cobblers annually. Last year he harvested an average yield of more than 400 bushels to the acre, all of which were certified. (June 10).—E. V. HARDENBURG.

RHODE ISLAND

Planting operations were completed about the 25th of May. The weather has been favorable and the potato fields, as a whole, look fine. Approximately the same acreage seems to have been planted as was planted last year by the majority of the commercial growers. Green Mountains and Cobblers are practically the only varieties planted. The Green Mountains are, by far, the chief variety. The Chippewas that have been planted have been very satisfactory yielders, whereas the

Katahdins have not been very successful. A ton to 2500 pounds to the acre of high potash fertilizer, such as 4-8-10 or 5-10-10 is rather generally used. (June 10).—T. E. ODLAND.

SOUTH DAKOTA

The acreage of certified seed potatoes is somewhat increased over last year; whereas the acreage of commercial potatoes is slightly below that of last year. Most of the potatoes are now planted, and moisture conditions are still very good. It is as yet, too early to make any statements regarding the presence of diseases, insects, or any other potato pests. The month of May and the early part of June have been cool with plenty of rain in most sections of the state. (June 11).—S. P. SWENSON.

TENNESSEE

We now have a very nice crop of Irish potatoes in prospect. Much of the earlier planting is ready to be dug. It has been an unusually good growing season with plenty of moisture,—in some places almost too much rain. I see no reason why we should not harvest a normal crop, with some improvement in quality. (June 8).—BROOKS D. DRAIN.

VERMONT

Potato planting was delayed from two to three weeks in the areas in this state, owing to excessive rains which rendered the ground unfit for plowing and fitting. Although favorable weather in July and August might improve the growth of the crop, it will be necessary to have a late growing season in order to obtain a heavy yield.

Certified seed, or seed from stock which has been under certification within a year or two, appears to have been generally used for planting throughout the state.

A sample of what is believed to be the original Gold Coin variety has been secured from a grower in Peru, Vermont, and sent to Aroostook Farm, Presque Isle, Maine for varietal experimental work conducted by the U. S. Bureau of Plant Industry. The Gold Coin was originated at North Bennington, Vermont, in the eighties, but the variety seems to be practically extinct in this part of the country, at least.

The samples entered by prospective growers of certified seed in the Central Test Plot at Randolph Center number approximately the same as last year—between 80 and 90. There is the usual preponderance of Green Mountain, with Irish Cobblers a poor second and a few entries of Katahdin, Chippewa, Russets, Spaulding and Early Rose. (June 15).—HAROLD L. BAILEY.

Wisconsin

At this date, the 7th of June, a very large percentage of the Wisconsin potato crop has been planted. In the Rural New Yorker area of Central Wisconsin a considerable acreage remains to be planted this week.

The potato planting conditions have been very satisfactory over the state. The growers in some local areas have been delayed, because of the cold wet conditions, but, as a whole, conditions have been favorable with respect to the soil and moisture.

Some of the larger operators report a slight decrease in acreage, but this may be offset by a relatively small increase among numerous farmers and smaller growers outside the main commercial areas. No significant change in acreage is noticeable in Wisconsin.

During the past ten days the staff members of the College of Agriculture have devoted most of their time to completing plantings of both experimental and extension projects. These projects include variety adaptations, potato breeding, scab control, fertilizer studies, potato discoloration studies, and work with green manuring crops.

Several of the county asylum farms located in the commercial potato growing counties have planted demonstration plots on an acreage basis using the well known standard varieties in comparison with newer varieties such as the Katahdin, Chippewa and Warba. We will have a good opportunity to observe the behavior of these varieties on a field basis this year. (June 7).—J. G. Milward.

REVIEW OF RECENT LITERATURE

Fertilizer experiments with potatoes. J. A. Chucka and D. B. Lovejoy. (*Summary Report of Progress,* (1935) *Maine Agr. Exp. Sta. Bul.* 380 (1935), *pp.* 147-150).

Permanent plots. The yields obtained on the two-year rotation series were again higher than those on three year rotation or on the continuous cropping series. This higher yielding capacity of the two-year rotation series is believed to be because of the larger amount of organic matter incorporated in the soil on the two-year rotation as compared with either the three-year rotation or the series cropped continuously with potatoes.

Fertilizer placement tests on potatoes. The placement of fertilizer in bands to the side of the seed pieces at approximately the

same level as the seed resulted in larger yields of potatoes than the placement of the fertilizer below the seed pieces or mixing the fertilizer with the soil.

Potash—magnesium test. Only a small response to magnesium added to 4-8-3, 4-8-5, 4-8-10 and 4-8-12 fertilizers was obtained on two farms and a very definite response on the third farm. In the series without added magnesium the highest average yield was obtained with the 4-8-7 fertilizer, while in the series with magnesium, the 4-8-12 fertilizer, produced the highest average yield. As indicated in previous years, the response to magnesium was greater in the fertilizers, both low and high, in potash than it was in the 4-8-7 fertilizer.

Acid versus neutral fertilizer test on potatoes. Fertilizers neutralized with calcium limestone produce somewhat lower yields of potatoes in Aroostook County than do acid fertilizers. Fertilizers neutralized with dolomitic limestone produce higher yields than acid fertilizers without added magnesium but they produce lower yields than acid fertilizers to which water soluble magnesium has been added. Therefore it would appear that the increase obtained from the addition of dolomitic limestone to potato fertilizers under Maine conditions, is caused by the magnesium contained in the dolomitic limestone rather than to the neutralization of the residual acidity of the fertilizer.

Rate of fertilizer application test on potatoes. Double strength (8-16-14) fertilizer was applied to both Irish Cobbler and Green Mountains at rates varying from 500 to 1500 pounds to the acre. Although the highest yield was produced by the heaviest fertilizer application, the increases in yields from applications of 8-16-14 fertilizer, greater than 750 pounds to the acre, were too small to justify the use of extra fertilizer in 1935. The data, as well as field observations indicate that water was one of the chief limiting factors in determining potato yields in Aroostook County during the 1935 season.

Uncommon element test on potatoes. This year's data from the test with manganese, copper, iron, zinc, and nickel in potato fertilizers indicate no general beneficial effect caused by the use of these elements.—ORA SMITH.

Irrigated crop rotations in Western Nebraska (1912-34). S. H. HASTINGS. (*U. S. D. A. Tech. Bul.* 512 (1936).

Potatoes have been grown in fifteen different cropping systems. There is one continuously cropped plot, four two-year rotations, untreated, and two which received applications of farm manure, one three-year untreated rotation and a similar rotation to

which manure was applied. There are six alfalfa rotations, two having two years of alfalfa, two having three years of alfalfa, and two having three years of alfalfa together with an application of farm manure during each cycle.

The lowest yields have been harvested from the continuously cropped potato plot.

The highest yields of potatoes for any period and for the entire twenty-three years have been harvested from the six-year rotation of alfalfa three years, potatoes, oats (manure), and sugar beets. Yields were only slightly less in the same rotation which received no manure. The benefits in the form of increased yields of potatoes from three years of alfalfa, as compared with two years, are clearly apparent.

Applications of farm manure have definitely stimulated potato yields. That rye, when plowed under, has had a beneficial effect in stimulating the yields of potatoes, is apparent when the yields from the two-year rotation of oats and potatoes are compared with those from the rotation of oats, followed by rye plowed under, and potatoes. The yield for the rotation of sugar beets and potatoes is about the same as that of oats and potatoes, but the potato and corn rotation has returned the lowest yield next to the continuously cropped plot.

Throughout the twenty-three year period there has been a marked variation as to the quality and size of the potatoes from the different rotations. Tubers harvested from the continuously cropped plots, and the two-year rotations definitely showed more scab injury, whereas in the longer rotations, particularly those including alfalfa, they were nearly free from the disease.

The highest percentage of cull potatoes has been harvested from continuously cropped plots. The next two highest percentages of culls were harvested from the two-year rotations of sugar beets, potatoes and potatoes, and corn. Applications of farm manure have reduced the percentage of culls in two-year rotations of sugar beets, potatoes and oats, and potatoes.

The consistently lowest percentages of cull potatoes have been harvested from the 4, the 6, and the 7-year alfalfa rotations.—ORA SMITH.

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SPRAYING STILL ADVISABLE

Numerous spray tests conducted for a long period of years have definitely shown that losses caused by insects and diseases may largely be prevented by the proper use of Bordeaux mixture. Practical growers have proven, to their own satisfaction, that they cannot secure maximum returns without spraying. Despite all this, it is safe to say that a large proportion of growers do not spray.

It is difficult to say why this is true. One reason for the failure on the part of the growers to adopt the practice more generally may be that the spraying operation is a time-consuming and an unpleasant task. It should be emphasized, however, that when a four row boom was used, it was considered that 10 acres a day was a satisfactory day's work. With modern equipment it is easily possible to spray 50 acres a day. Many growers are constantly experimenting with simpler methods, some of which, although much more rapid, are not satisfactory substitutes for spraying. Where the leafhopper or late blight is a factor we have still to discover material to replace Bordeaux mixture. There is no question but that we should continue to give serious attention to the development of a satisfactory substitute for Bordeaux mixture, but at present none is available.

This past spring we had numerous complaints of late blight rot in seed from northern states. The presence of this disease did much to shake the confidence of the buyer in the value of seed potato certification. A recurrence of this situation should be avoided. The seed grower cannot afford to risk an outbreak of late blight. He should see that his crop is thoroughly sprayed throughout the season. If this is done, there will be fewer complaints of rot in seed potatoes.

Potato spraying continues to be one of the important steps in the production of the crop. The growers who produce the largest yields appreciate this fact. They know it is a real asset in keeping the cost of production down. It is unfortunate that more growers do not adopt the practice.